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Participatory Science Communication for Transformation

For real-world outcomes you need real-world training: participatory capacity building in science communication

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Abstract

Concepts underpinning participatory science communication have much to offer science communication training and capacity building. This paper investigates a capacity building program with 15 science communicators from nine African countries involved in a six-week program in Australia. Data was collected via surveys, observations, informal interactions and ongoing relationships tracking program outcomes. Key features with a participatory nature included: holistic programs giving participants diverse skills and entry points; ensuring participant's freedom, agency, autonomy and self-efficacy; real-world networking as a self-directed participatory process; participant-led design processes to build skills for creating programs; and, embedding training in real-world contexts with deliberately selected publics.

Keywords

Professionalism, professional development and training in science communication; Science centres and museums; Science communication in the developing world

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Introduction

Participatory modes of science communication — from researcher's public engagement to free-form tinkering in science centres — are argued as ideal [Stocklmayer, 2013], but in practice science communication tends to favour deficit and dialogue modes [Metcalfe, 2019]. The same is arguably true in science communication training. This paper employs concepts from participatory models of science communication to reflect on and improve science communication training.

Aspects such as valuing and trusting participants to shape and control their own training, codesign between trainers and trainees, and providing scope for participant's autonomy and freedom in training activities are logical extensions of participatory tenets in science communication. They are, however, not always straightforward to implement — often for logistical reasons, but sometimes due to the fundamental design of training, spoken and unspoken power imbalances or perceptions of expertise, or the self-efficacy of participants. While these are issues for science communication training, they have direct parallels in science communication practice — fundamentally, this paper is about applying insights from broader science communication practice to enhance training.

This reflection explores science communication capacity building and training in an international context, with focus on science centres and public/school engagement programs. Throughout 'participation' is thought of in a broader sense than the research/public/policy sphere it is typically associated with, extending underlying participatory features (e.g. two-way, participant-driven processes) to the training context.

First, I review current approaches to science communication training focussing on science centres, then discuss some nuances of this when applied to capacity building in international development contexts. From there, I introduce a case study of a science communication training and capacity building, *Science Circus Africa*, and reflect on preliminary data from a six-week training program as part of a wider capacity building initiative. Note here 'Africa' is used for brevity, however the project involved nine countries and using this collective term does not intend to diminish the unique cultures and science communication approaches present in individual nations.

Before diving in, it is worth highlighting the differences between training and capacity building (or capacity development). Training tends to focus on transferring knowledge and skills to individuals, whereas capacity building is more holistic spanning individuals, organisations and whole sectors or systems [United Nations Economic and Social Council, 2006]. Furthermore, capacity building places greater emphasis on the contextual and cultural setting of participants and fostering their independence [Pearson, 2011]. Thus, capacity building is more participatory; the deficit-like transfer of skills in training is expanded on with consideration of the wider context, participants' circumstances and holistic longer-term outcomes. Training, however, may be part of a broader capacity building effort. In this paper, I use the most appropriate term for the context, however sometimes boundaries are fuzzy.

Science centre capacity building and training: what does participatory practice look like?

Science centre capacity building or training takes many forms, from ad-hoc training often with an 'on-the-job' component, to curated short courses run by centres (e.g. Technopolis's Science Centre Academy) and universities (e.g. the case study below), through to longer-term relationships which are essential for capacity building. Some universities offer degree programs, such as the Australian National University's Master of Science Communication where students undertake fieldwork with the Questacon Science Circus outreach program [McKinnon and Bryant, 2017] and Laurentian University's Masters program with Canadian science centre Science North. These approaches deliver learning in authentic real-world science centre/professional outreach settings, in addition to 'classroom' learning. Including real-world settings gives scope for participatory science communication as a training output, but not necessarily as part of the training process.

While considerable science centre training occurs, there is little published research on its methods, outcomes or effectiveness when compared to training for scientists. A review of science communication training programs, which divided learning outcomes into the six strands identified in the Learning Science in Informal Environments report [National Research Council, 2009; Shouse et al., 2010], identified a gap in documented learning objectives for science museum/centre training:

> "Across all the strands, most of the items referred to media and to outreach events or activities; relatively few items referred to science museums (a major site of science communication)." [Baram-Tsabari and Lewenstein, 2017, p. 289]

When looking at the strand related to learning content knowledge, where other areas of science communication have developed detailed lists of learning goals, the review paper went on to say:

> "To our knowledge, similar lists do not yet exist for museums or social media or public presentation and deliberation. Thus, we call attention to the need to develop more specific learning objectives for these areas." [Baram-Tsabari and Lewenstein, 2017, p. 293]

Given this review investigated training described in 20 research papers, some review papers in themselves, this underscores the research gap in what science centre training and capacity building should entail.

Researchers have, however, identified training methods used broadly in science communication relevant to science centre training, and also present in the *Science Circus Africa* capacity building program described later. Key amongst these is that training should be authentic, i.e. it should be as close to or actually involve real-world science communication to external audiences — an approach also emphasised in tertiary education [McKinnon, Orthia et al., 2014]. While this may seem an obvious choice, Baram-Tsabari and Lewenstein [2017] noted that few training programs "emphasized the element of participation" (p. 295) and went on to note this is counterproductive as authentic training methods not only train, but communicate science too — the end goal of such training.

Silva and Bultitude [2009] reached similar conclusions investigating trainers and trainees — both scientists and science museum/centre explainers — in 47 different STEM communication training programs. Their analysis teased apart training methods and assessed effectiveness according to different participant groups. Overall, they found an *interactive* style to be essential. They also highlighted two other strong themes: *demonstration followed by own performance and feedback*; and *practice at live event* (italics indicate training categories identified) — both qualities found in authentic training settings, or "learning by doing" [Silva and Bultitude, 2009, p. 9]. One trainee summed this up saying "In my mind, the best way that you can be trained it is to actually go and do it yourself. And when you're doing that you have someone else to give you a bit of feedback" [Silva and Bultitude, 2009, p. 9].

Silva and Bultitude also stressed the important role of real-world audiences, making the distiction between *role play* where the audience is internal (other trainees and the trainers) and a real-world or authentic audience, stating:

> "Many respondents believed that a real event with a live audience removes the artificiality often associated with a role play scenario, where the audience is "not real". Therefore, being able to practice within the proper event setting strengthens and consolidates the learning and confidence of trainees." [Silva and Bultitude, 2009, p. 9].

This research yielded additional guidelines for best practice including: trainee discussion and reflection; contact between trainees and peers and sharing of experiences; use of multiple trainers; tailoring of training to the specific group and/or understanding the trainees' needs, expectations and abilities; and, improving training materials. These are all opportunities for participatory approaches to be part of the training process, not just training outcomes or contexts.

Capacity building in an international science communication development context

Capacity building and training in an international development context have additional considerations, particularly around the motivation for training and the relationship between those providing and receiving training (noting, importantly, that capacity is built in both directions). Motivation can be divided into individual participant motivation and broader impetus for the training program.

In their review of training programs, Baram-Tsabari and Lewenstein [2017] separated the role of intrinsic (i.e. personally valued, useful and worthwhile for its own sake) and extrinsic motivation (i.e. valued by an organisation or other external factors). This distinction is apparent in international development contexts. In the case study described later, participants could be roughly divided into 'pioneers' — individuals working alone, often unpaid, or with small volunteer teams — and institutional employees, who were primarily involved in training due to goals of their institution or government policy. Although overlap surely exists, the former are arguably more intrinsically motivated while the latter extrinsically motivated.

When reflecting on longer term outcomes across the group described in the case study, the greater the proportion of intrinsic motivation, the more significant and sustained outcomes have been. Given the scarce resources for international capacity building, understanding potential participant's motivation for science communication in particular is important — and those driven *solely* by institutional or external personal factors (e.g. the status bestowed by involvement or the opportunity for a trip or allowance) should be carefully vetted. That said, those working within a supportive organisational and policy environment have far fewer barriers and many more assets to maximise the outcomes of training [Walker et al., 2020]. Motivation is hard to measure and easy to imitate so who to train when resourcing is limited is a conundrum; in my experience the long-term relationships in capacity building are the most robust test.

Turning to what motivates capacity building initiatives more broadly, an ecotourism guide training program in Central and South America described by Weiler and Ham [2002] notes the importance of motivation for training coming from the recipient country or individuals — something also highlighted in non-international training settings [Silva and Bultitude, 2009]. Weiler and Ham [2002] identify advantages it lends the training program which are even more critical in their train-the-trainer methodology:

> "In order for training to meet the needs of a country or region and contribute to sustainable development, the impetus for training must originate in the host country. This is true of any kind of human capacity building . . . keeping the ownership of each course firmly in the hands of local (host country) players helped ensure that the objectives of each course were appropriate to the host country, and that those who most needed the training were given the opportunity to be there. Host country initiation and ownership of the training curricula and materials are important elements of sustainable capacity building." (p. 55–56).

Having capacity building instigated and owned (at least to some degree) by the participants themselves creates a more balanced trainee-trainer dynamic and provides greater scope for participatory design and training activities; training is being done *with* rather than *to* recipients. As with science communication more broadly, the power balance between different actors is critical to the nature of subsequent interactions.

In our experience with science centres, however, the motivation for training is often the result of an informal participatory process, especially in regions with few or no centres and little public awareness of the approach, such as large areas of Africa [Trautmann and Monjero, 2019]. For example, a recent capacity building project in Myanmar was inspired only after a first-time visit to an Australian science centre (and indeed Australia's first science centre, Questacon, and early capacity building was inspired by the Exploratorium in the United States). The science centre visit, motivated by the organisation delivering subsequent training, acted as a probe — a tool to promote reflection or 'thought starter' [Sanders and Stappers, 2014] for subsequent codesign. In this case there was shared motivation for capacity building, with both the inception and subsequent codesign of activity arrived at through formal and informal participatory processes.

As with participatory practices in other areas of science communication, codesign helps ensure relevance and ownership [Orthia et al., 2021] and promotes the agency of participants/trainees. This fosters participant's independence, values their capabilities and gives autonomy to shape their own training and subsequent science communication — ultimately it provides participants *freedom*, a theme argued as seminal in development studies [Sen, 1999].

Capacity building context: *Science Circus Africa*

Science Circus Africa aims to further develop African capacity in STEM communication and education, with a focus on developing outreach/engagement programs and science centres. The project's principal supporter is the Australian Government Department of Foreign Affairs and Trade. Three key approaches to capacity building — all founded on strong partnerships — are employed: (1) travelling public engagement programs with 'on-the-job' training in Africa, (2) broader capacity building short courses in Australia (the research presented here), and (3) ongoing informal interactions, mentoring, networking and knowledge exchange [for more see Walker et al., 2020]. These approaches embody many of the characteristics highlighted in the literature reviewed earlier, most fundamentally that activities are embedded in real-world science communication and ultimately led and owned by African individuals and organisations (noting there may be shared ownership especially early in relationships and during codesign processes). While this authentic real-world focus has proven effective for building capacity in African individuals and organisations, it is also critical for fundraising and providing immediate benefits to publics.

As part of an Australia Awards Fellowship short-course program, a six-week capacity building program was devised based on 14 years of collaborative programs in Africa, interactions with potential and actual participants, a short survey, and fundamental content related to science centres and engagement programs. This gave a degree of codesign, however resourcing and timelines of the project limited depth — ideally a more participatory, multistage process would have been used. The activities/objectives of the training program are outlined in Table 1.

Table 1. Summary of the capacity building program.

Objective	**Example training / capacity building activity**
Understand science centre design and development	Teams designing and creating pitches for different sized centres
Explore centre models and operations through science centre visits	Visits, interactions with industry professionals, networking, in-context evaluation
Increase skills in volunteer/staff management and training	Role plays to understand different staff roles in the centre
Build skills in sponsorship and government engagement	Writing a mock or preferably real grant application
Apply strategies for content creation (science shows, workshops, exhibits, etc.).	Conceiving and building exhibits for an exhibition for school audiences
Develop evaluation skills and tools	Creating surveys for participant's programs, evaluating exhibits based on visitor behaviour
Apply strategies to enhance local relevance and cultural responsiveness	Designing content to address key country-based issues
Design programs to foster inclusion and equity	Sessions from a disability expert and a blind African scientist followed by running programs for students with disabilities

The training program employed strategies recommended in the literature, including running authentic programs as part of the training. An illustrative example concerned interactive exhibits whereby trainees first explored exhibits at science centres and through the seminal Exploratorium Cookbooks [Bruman, Hipschman and Exploritoium Staff, 2002], which were given to them along with their own hand and power tools. They then adapted or devised novel exhibit designs, developed a brief, shared peer and expert feedback, built it and tested them in an exhibition where students from two schools attended, including students with disabilities. This follows Silva and Bultitude's [2009] *Demonstration followed by own performance and feedback* and *Practice at live event* formats.

Subsequently, the skills, tools and Cookbooks have led to the fabrication of many more exhibits in participants' home countries, with sustained activity over time, and use by thousands of students and the public — the capacity building has been effective (see Figure 1). I explore some of the key underlying reasons for this in the next section.

Figure 1. A tweet by a Kenyan participant showing his exhibit and subsequent use. The exhibit, based on a classic two-way mirror and lighting effect, blends two people's faces together to convey optics concepts. In Kenya, however, it was also used to promote ethnic harmony during election violence by highlighting what they have in common through the symbolism of blended faces.

Participants views on effective participatory capacity building

Participant's perspectives were investigated through pre, post and follow-up surveys, observations and conversations during the program, discussion and assessment of outcomes, and informal ongoing interactions. A number of themes emerged that demonstrated the value of participatory methodologies. The themes described below are primarily drawn from qualitive analysis/coding of post-program surveys, with broader contextualisation based on other data sources noted above. Coding and broader reflection showed many linkages between these themes; like many participatory processes, individual elements and training experiences connected in ways that weren't anticipated by the program designers.

Holistic approach

Unlike larger science centres, many participants were responsible for multiple or all activities of their organisation, or operated as one-person NGOs, hence the program covered a diversity of science centre operations. Participants connected these in unique ways based on their cross-cutting roles, influenced by their own circumstances and goals. The holistic approach allowed different entry points and freedom to engage on participants' terms, a key foundation for effective participation.

> "I can now develop educational shows, interactive exhibits, outreach and teacher programmes [and] write and present proposals and grant applications to potential sponsors for funding. I now have an idea how to start and run the science centre, which was something new to me. I can evaluate our programmes, shows and exhibits." — South African participant.

Freedom

In line with common aims of capacity building, the program aimed to build participants' agency, autonomy and self-efficacy and provide flexibility for participants to explore and develop content relevant to them, their countries and deeper identity. Data revealed the holistic process described above was key to this — it allowed participants to use a portfolio of skills over an extended process which built their self-efficacy, especially when coupled with presenting outcomes (e.g. exhibits) to authentic audiences. This freedom allowed participants to find advantages and overcome constraints of their home contexts:

> "Building ... interactive exhibits which are not too complex for the learners, cost effective as compared to buying readymade, sophisticated exhibits. Because the exhibits are built in house, it is easy to repair them [and] change the exhibits as necessary." — Botswanan participant.

Freedom was also key to creating a space for participants to find relevance and approaches that would fit in their countries, and self-efficacy to implement them:

> "The project has inspired and given me extra strength to establish a science centre of our own. We were worried with where we would get exhibits, but with the training ... we are more confident that we can produce exhibits of our own that will have Malawian touch and relevance." — Malawian participant.

When viewed as a participatory rather than deficit practice, a key issue in training environments is how to address power imbalances and real or perceived imbalances in expertise. As a trainer and trainee, it is easy to act as if one has all the answers and one is an empty vessel to fill, respectively — this is not a recipe for impactful training and something many trainers, including me, learn the hard way. A participatory approach, however, calls for more balance and reciprocity between the two. Programs that prioritise giving autonomy in a supportive confidence-building environment go some way to addressing power imbalances and creating a space where participants also bring significant value to the training process.

Networks

Interactivity is a key aspect of participatory science communication [Trench, 2008] and in the context of the capacity building program interactivity between participants and externally were critical. The networks, especially between participants, gave confidence they were part of something bigger and could draw on new relationships to collaborate or bolster individual endeavours.

> "I feel empowered, exposed and connected. I was exposed to diverse science centres that I related to and ... aspire to. The fellowship broadened my network ... there are more opportunities to learn from, and collaborate with each other. I felt empowered." — South African participant.

A reflection from organisers is we should have made more deliberate efforts to formalise the network between participants during and immediately after the program, rather than assume it would happen organically (which it did). This also exposed a tension in codesign and efforts to maintain equal power balances and promote agency: participant data showed a more formal network was desired, however when it was suggested participants themselves should lead that initiative there were mixed views. This may have been due to underlying trainer-trainee power imbalances. In time, more active participants took on the role of maintaining networks and this led to numerous instances of collaboration between African countries — travelling programs, science festivals and online events (especially during covid) have been particularly rich methods. It is far less likely this would have happened if the network was not participant led and controlled.

Design skills

Due to limited resources and ensuring local relevance, creating content like science shows and workshops or building interactive exhibits in-house is a key capability for emerging African science centres. While considered in previous travelling programs in Africa, the longer period of the program described allowed participants to take more control of the process. This created tangible outcomes while also increasing participants' skills — both practical such as using power tools and process-oriented such as designing exhibits — and critically self-efficacy. Data from participants overwhelmingly spoke to its central role.

Design, due to the inherent nature of the process, of a science communication program or artefact is a highly participatory endeavour, however reflecting on our process and how it was scaffolded highlighted several key aspects. Many of these balanced practicality and structure — which was important to ensure success in the timeframe, ensure participants didn't feel overwhelmed, and make the program logistically manageable — with giving participants wide freedom and scope to take an asset-based approach (i.e. build on their own strengths, areas of expertise, or resources they had access to in their home countries, etc.). Asset-based community development approaches have strong practical and theoretical links to participatory science communication [Walker et al., 2020].

Focussing on the most in-depth design activity — creating interactive exhibits — we began by giving participants complete control as to the aim of the exhibit, alongside experiences/resources such as science centre visits showing the breadth of what exhibits could communicate (e.g. simple phenomena, social/global issues, behaviour change, etc.). For these experiences to be an effective probe to inspire and shape the exhibit concept in the pre-design phase [Sanders and Stappers, 2014], reflection on experiences was essential, e.g. discussing and evaluating exhibits. This was done as part of science centre visits which we hoped would organically cross-pollinate design activities; it was only afterwards we fully realised the importance to the exhibit design process — more deliberate integration would have helped. Participant's exhibits ranged from simple phenomena-based ideas such as levers to communicating the Sustainable Development Goals using electronic circuit based quiz.

Several exhibits tapped into more impactful forms of relevance as categorised by Priniski and collegues [2018, categories are indicated in brackets] to home countries, such as a Ugandan house model with a solar/wind powered water pump (relevance as personal usefulness) or a two-way mirror exhibit named *Everyone is You and Me* used to foster community cohesion during ethnic violence in Kenya (relevance as identification; see Figure 1 above). The basic design concept for the latter example came from an Exploratorium Cookbook, however the context and relevance emerged from the designer's lived experience. It summed up, but also greatly exceeded, what we aimed for in the design process and would not have been achieved without giving participants freedom.

Participants were given a template to capture their design, materials required and promote reflection about the user experience. Program staff then sourced the materials, however participant data showed they would have liked to and in hindsight should have — it is critical experience and a powerful way to finesse designs, but was omitted mainly due to time pressure. Providing autonomy versus ensuring efficiency was a constant capacity building tension. Participants then led their making process at a science centre makerspace (which had spin-off benefits) with careful non-intrusive facilitation based on tinkering approaches [Anzivino and Wilkinson, 2012] to maximise learning, self-efficacy and autonomy — however there was again tension between giving autonomy and ensuring safety during making and public use. Like science communication more broadly, the inherent autonomy in participatory methods introduces risks — sometimes these can be beneficial, but safety is one clear exception.

The culmination of the process involved an exhibition at the Botswana High Commission function centre for two schools, in line with guidance re having authentic real-world audiences and settings for training activities. Program partners, funders, and staff and families of the High Commission also attended. This provided networking opportunities leading to a participant negotiating with the High Commission to freight large exhibits back to Botswana — in addition to the valuable authentic audiences, real-world training means real-world spinoff benefits. Participatory aspects of the capacity building program often combined in unexpected and helpful ways — giving freedom means trainees can go beyond premeditated outcomes. Having the real-world event as the capstone also motivated trainees — they knew they would be appraised by more than their peers and trainers and there was a hard deadline.

Data showed the design and school exhibition experience along with resources (physical tools, books, templates, etc.) were key to producing longer term outcomes such as applying the training when returning home (see Figure 2), shown by this comment:

> "[An important outcome was] being able to design exhibits and science shows. The experience is key for the development of a sustainable science centre. It built confidence in myself; [I can] make exhibits for the first science centre in Zimbabwe using the skills and resources from the training. I will make use of the equipment donated to us."

Figure 2. A tweet showing a set of exhibits built in Zimbabwe — an impact of the exhibit design training. In this case exhibit concepts came from supplied resources, other participants, visits to science centres and the participant's ingenuity, showing the role of the training program, networks and participant's freedom respectively.

Authentic real-world contexts and publics

As highlighted in the above case study on the exhibit design process — but regrettably not applied in all aspects of the program — embedding the processes and outcomes of capacity building in real-world settings had a range of benefits for participants and linked strongly with other participatory aspects of the program. These included the self-efficacy that comes with success and overcoming challenges, broader external networking, having a genuine experience and a 'test' of newfound skills before using them outside the training setting, and learning and encouragement from audience feedback and interaction, as summed up in this comment:

> "Build[ing] my own exhibit ... inspired me because I never thought that I could do it. The knowledge gained from having to design it, build it and explain it to people were very inspiring, especially when kids came again and again to have a look at it and use it ... explaining it to people is priceless knowledge and motivation." — South African participant.

As noted by Baram-Tsabari and Lewenstein [2017] discussing the lack of emphasis on authentic settings for training, "the goal of most science communication training programs (and their funders) is to increase the amount of science communication that occurs" (p. 295) and hence real-world training contexts are a win-win. The extension to this argument speaks to the benefits for publics both from training-embedded programs and those that lead from them. These can be profound, and highlight the importance of carefully choosing real-world settings and particularly publics. In our training program, a combination of intended design, staff expertise and funder priorities meant we focussed on people with disabilities as one of those publics. Training outcomes showed a direct link between engaging this group during training and trainees subsequently creating programs for them. A majority of participants specifically noted people with disabilities in their follow up plans, while in one case it led to an in-country training program and establishment of programs for autistic children in Zimbabwe — for a heart-warming example of the outcomes see https://twitter.com/zimsciencefair/status/880337555283210240. Without targeted inclusion of the specific public in the training program, it is unlikely outcomes for such audiences would be realised.

Conclusions and recommendations

This reflection explored ideas for enhancing training and capacity building programs when viewed through the lens of participatory science communication methods. Prior to any program, the motivation both of individual participants and the program as a whole — which should be driven by participants — should be considered. This ensures individuals most likely to create impact are involved and there is balance in the program design and power dynamic of trainers and trainees. This creates a space for codesign, however this is by no means straightforward and as a science communication process requires further research.

By focussing on participatory methods, we identified helpful underlying features of training and capacity building programs useful for future programs:

– A diverse, holistic, codesigned program allows participants to make novel connections, prioritise elements based on their goals, and develop a range of integrated skills.

– Allowing participants freedom — i.e. agency, autonomy and environments to foster self-efficacy — to develop skills that match real-world activity and, critically, provide scope for participants to discover and create what is most relevant to them — what they identify with at a deeper level. This is near impossible to intentionally design into a training program, rather programs need to create space for participants to discover it themselves.

– Networking, which could be considered an informal participatory practice in itself, was a powerful way of tying other participatory elements together and a key skill to develop.
– Well (but not overly) scaffolded participant-led design processes were key to building self-efficacy, providing a context for freedom and creativity, and allowing participant's deep understanding of their immediate publics to come into program and exhibit design.
– Using authentic, real-world audiences wherever possible had a range of benefits for participants, but also provided benefits to audiences and built strong foundations for transferring training to real-world impact. Involving specific publics in training activities led to real-world outcomes for these groups, a key consideration when addressing equity and inclusion in science communication.

A shortfall of this paper is that it too could have been a participatory exercise, which would have brought benefits to the author, untapped authors, future training programs and you as the reader.

As noted by others [Irwin, 2008; Masson, Metcalfe and Osseweijer, 2016] when thinking about the practice of science communication, certain publics — or in this case participants of training and capacity building programs — have much to contribute when a welcoming space for dialogue and participation is opened.

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